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SCHOOL OF AGRICULTURE

Agricultural Experiment Station

Collar-Blight and Related Forms of Fire-Blight

C. R. ORTON & J. F. ADAMS.

STATE COLLEGE, CENTRE COUNTY, PENNSYLVANIA

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BULLETIN No. 136.

COLLAR-BLIGHT AND RELATED FORMS OF FIRE-BLIGHT

BY C. R. ORTON AND J. F. ADAMS.

INTRODUCTION.

The forms of disease of the apple, pear, and quince caused by the fire-blight organism are the most serious troubles with which the Pennsylvania apple grower has to contend. That form of blight which attacks the trunk of the tree near the ground, and which may be known as collar-blight, is especially troublesome. The fact that published information on collar-blight and its related forms is not readily available for many orchardists makes it seem advisable to issue the present bulletin on the subject.

HISTORY.

Collar-blight in Pennsylvania was first brought to the attention of the Experiment Station[1] by an orchardist in Franklin County, where it had appeared in a block of fourteen-year-old apple trees. It undoubtedly was prevalent in the State for some years previous to this time, but owing to the relatively slight attention previously given to commercial apple culture in Pennsylvania its presence was overlooked. With the awakened interest in fruit growing and the recognition of the importance of cultivation and fertilization in orchards, especally favorable conditions were brought about for the development of this disease, and it was soon recognized. Some of the old orchardists of the State claim that the disease has existed in Pennsylvania for fifty years, but the earliest authentic record obtained from correspondence with orchardists places its inception at about 1900.

That the disease is not a local one is shown by references to it in the published reports and bulletins of several State experiment stations and it would seem now to be rather widespread in New York, New Jersey, Pennsylvania, Maryland, Virginia, West Virginia, Ohio, Illinois, and Oregon. It probably occurs to some

[1] Stewart, J. P. Pear Blight on Apple Trees. Rural New Yorker, 66:765. 1907.

extent in nearly all of the apple-growing sections of the United States. What is apparently collar-blight is referred to by Selby[2] in Ohio as destructive to Grimes Golden, Tompkins King, and other varieties of apple. Whetzel[3] refers to collar-blight in the following words: "The large cankers at the bases of young trees, frequently referred to by growers as 'collar-rot', are in many cases very probably due to the same causes as that of the cankers on the upper parts of the tree."

Grossenbacher[4 & 5] has published two bulletins dealing with what he calls "crown-rot." He came to the conclusion that practically all of the injury at the collar of trees was due to winter injury. In view of our experience in Pennsylvania, where collar-blight is so prevalent, and of Whetzel's observations in New York, which confirm our work, it seems extremely improbable that all the collar diseases described by Grossenbacher can be due to winter injury. At least, until more thorough investigations are carried out with regard to the possible presence of parasites in the cankers which he describes and illustrates, considerable doubt will be attached to his conclusions.

R. E. Smith[6] refers to collar-blight in California as occurring in orchards where fire-blight is present and where, as he says, "it appears that certain roots have been badly injured and that the portions affected above ground correspond with such roots."

Jackson[7] refers to the prevalence of collar-blight in Oregon stating that, "it is this form of the disease that causes many trees to be killed outright."

Giddings[8] reports that collar-blight is one of the most serious diseases of the apple in West Virginia.

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[2] Selby, A. D., Ohio Agric. Exp. Sta. Bull. 121:15. 1900.

[3] Whetzel, H. H., Blight Canker of Apple Trees. 13th Ann. Rept., New York Dept. Agric. **1905**:125.

[4] Grossenbacher, J. G., N. Y. Agric. Expt. Sta. Technical Bull. 12. 1909.

[5] Grossenbacher, J. G., N. Y. Agric. Expt. Sta. Technical Bull. 23. 1912.

[6] Smith, R. E., and Smith, E. H., California Plant Disease. Cal. Agric. Exp. St. Bull. **218**:1155. 1911.

[7] Jackson, H. S., Diseases of Pomaceous Fruits. Biennial Crop Pest and Hort. Report. **1911-12**:245. 1913.

[8] Giddings, N. J., The Rept. W. Virginia Dept. Agric. **29**:15-19. 1913.

Pickett[9], in Illinois, says that "the most serious of these hold-over cankers in apple trees are probably the large ones which are found on the larger branches, in the forks of the branches, and, in certain cases of 'collar-rot', in large areas on the trunks just above the surface of the ground." This disease undoubtedly has been referred to in other literature pertaining to fire-blight but not in such definite terms as to call for citation.

ECONOMIC IMPORTANCE.

So far, collar-blight appears to be almost exclusively a disease of the apple tree, but in 1913 there was one report from Bucks County of its occurrence upon pear trees where it was even more serious than upon the apple. There would seem to be no reason why other hosts of the fire-blight organism should not be attacked under conditions similar to those in which the apple is susceptible.

At the present time collar-blight is considered one of the most serious diseases of apple trees in Pennsylvania, not because of its

Fig. 1—Collar-blighted trees removed from a single orchard. Should be utilized immediately for fuel or burned.

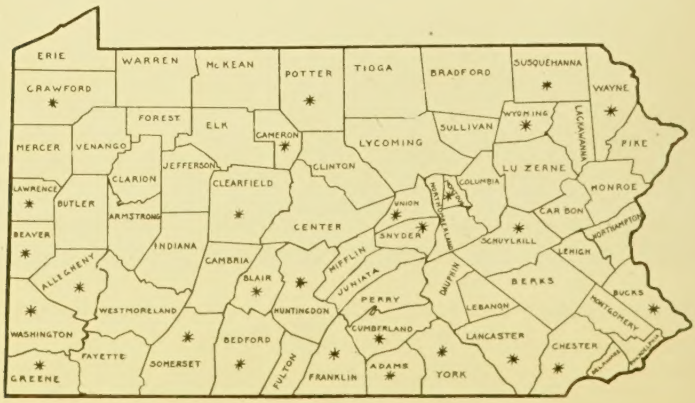
[9] Pickett, B. S., The Blight of Apples, Pears, and Quinces. Illinois Agric. Expt. Sta. Circular 172:5. 1914.

liability to reduce the proceeds from any one crop to a considerable extent, as some of the fruit-attacking fungi often do, but because of its attack upon the trees at the most critical period of their life, and the difficulty of treatment and the control of its further spread. Some large apple growers in the State have lost so many trees from this cause that they are much discouraged about apple growing and are on the point of replacing their apples with peaches (Fig. 1).

The loss from collar-blight alone in Pennsylvania is conservatively estimated at two per cent. annually.

DISTRIBUTION OF COLLAR-BLIGHT IN PENNSYLVANIA.

A rather careful survey was made in the fall of 1913 to secure information on the occurrence of collar-blight in this State. To this there have been added the reports received in 1914. The accompanying map will show the distribution of the disease by counties, a star representing its occurrence in a county. The disease appears to be most prevalent in our larger apple-growing sections, as might be expected. Undoubtedly it is present in counties not reported here and may be expected to occur wherever the apple is grown to any considerable extent. It is to be noted that in 1910, when a study of the disease was first taken up at this Station, it was known definitely to occur in only five counties. It is represented now in 27 counties, according to the accompanying map.



SYMPTOMS.

The early symptoms of collar-blight are usually evident during the growing season by a more or less unhealthy appearance of the foliage. The leaves appear yellowish and smaller on one or more of the large limbs as contrasted with normal foliage. When infected areas on the trunk progress slowly and extend through two or more seasons, the foliage, especially on that side of the tree affected, is rather sparsely developed (Fig. 2). Since this effect on the foliage is rather gradual, it does not result in the wilting or drying of the leaves in contrast to fire-blight infection of twigs. The ultimate effect on the foliage in all cases is the premature falling of the leaves.

Fig. 2—Typical appearance of foliage on tree affected with Collar-blight.

The general yellowing of the foliage facilitates the recognition of infected trees during the growing season. On examination of the collar of such trees there will be found a sunken area of variable size depending upon the time which has elapsed since in-

fection took place. Newly infected areas are not sharply marked off as in the more advanced cases. The disease progresses rapidly until midsummer when its development is arrested. During the next season activity is renewed, the attack often resulting in the complete girdling and subsequent death of the tree (Fig. 3). The girdling at the collar may be said to be the usual method of development but often, under certain favorable conditions not yet ascertained, the blight may extend very rapidly up one side of the

Fig. 3—Symptoms of Collar-blighted apple tree in late stages.

trunk into the branches, and thus cause sudden death (Fig. 4). In some cases it has been observed to extend downwards, thus affecting the lateral roots for some distance.

Usually it is not until the second season of infection that the characteristics of the disease above the ground are clearly defined. A distinct line of demarcation separates the normal tissue from the lesions, which appear to be water-soaked and browned, eventually separating from the sap-wood (Fig. 5). The diseased tissue

emits a sour odor and often small milky drops exude which consist of masses of bacteria. Pure cultures of *Bacillus amylovorus* have often been isolated from these exudations. The sap-wood becomes browned and later blackened.

Fig. 4—Collar-blight, showing rapid progression up the trunk.

During the second season the foliage is usually scanty, and it is common for such trees to blossom heavily and to set fruit which develops under size and inferior in quality with a tendency to fall early. Attempts at healing which have prevented complete girdling have been observed often. In some cases of apparent normal healing, further extension of the infected area has been caused by borers working from the old lesions through the callus into the uninfected region.

COLLAR-BLIGHT VERSUS "WINTER INJURY" AND "ROOT-ROT."

Collar-blight is distinctly different from what has been called "winter injury" and from some forms of "root-rot" which often

Fig. 5—Typical Collar-blight, showing loosening of bark and blackening of sap-wood.

extend above the ground. In "winter injury" there is usually a sudden killing of the bark and cambium by freezing. Weather conditions which cause it are successive periods of freezing and thawing. "Winter injury" usually occurs on the southwest side of trees. It is noticeable at the beginning of the growing season, but in no case is there the progressive dying such as we find in the collar-blight. Oftentimes the winter-injured bark splits, loosens, and rolls back from the sap-wood and the latter is discolored, but there is not the water-soaked appearance of the diseased bark that is observed with collar-blight. In the case of this disease there is a distinct progressive death of the bark and cambium which is not usually observed until midsummer.

Root-rot may be secondary to "winter injury" and collar-blight or infection may first take place in wounded roots and the disease gradually work upward, killing the bark above ground in a manner somewhat similar to collar-blight. The appearance of whitish mycelial growth on the affected roots will serve to distinguish this disease from collar-blight or "winter injury." A softening of the wood occurs also in the case of root-rot. Conclusive evidence of root-rot is furnished when the fruiting bodies or mushrooms appear above the ground around the base of the trees in midsummer or later.

THE CAUSE OF COLLAR-BLIGHT.

The junior author has carried out continued investigations with regard to the cause of collar-blight as distinguished from "winter injury" and root-rot. Only one parasitic organism has been isolated from these cankered areas. This was *Bacillus amylovorus (Burr) deToni*, the cause of the well-known fire-blight disease of pomaceous trees. *Sphaeropsis malorum* was found growing frequently in the blighted bark and even, in some cases, down on the dead roots below the ground. Repeated inoculations with this fungus always have failed to produce a canker, and it is believed to be only a saprophyte on the bark following collar-blight as regularly as it does twig and canker-blight.

Bacillus amylovorus has been inoculated directly from pure culture and from diseased bark into the collar and roots of young apple trees, and typical cases of collar-blight have resulted. A report of inoculation work has been made elsewhere[10] by the authors. More work remains to be done in order to determine the optimum time of infection and the active period of development of the organism at the collar, but the authors regard the fire-blight organism as the cause of a majority of the collar diseases of the apple tree in Pennsylvania.

VARIETIES OF APPLES SUSCEPTIBLE TO COLLAR-BLIGHT.

The following data, bearing on the apparent resistance or susceptibility of apple varieties to collar-blight, have been compiled

[10] Orton, C. R., and Adams, J. F. Collar Blight of Apple Trees in Pennsylvania, (abstract) Phytopathology 4:43. 1914.

from reports and observations in the State. Only where there are two or more reports on a variety does that variety appear in the list.

	Variety	Number of Times Reported Resistant	Number of Times Reported Susceptible
1	Baldwin	8	8
2	Ben Davis	2	7
3	Fall	1	2
4	Grimes Golden	2	12
5	Haas	2	..
6	Maidens Blush	..	2
7	Northern Spy	3	2
8	Pewaukee	..	2
9	Fallawater	..	2
10	Rhode Island Greening	4	2
11	Russet	1	1
12	Smith Cider	..	2
13	Smokehouse	2	1
14	Sutton	1	1 bad
15	Twenty Ounce	..	2
16	White Pippin	2	..
17	Wolf River	2	..
18	York Imperial	..	14

Judging from the work and observations by the writers, as well as from the information noted in the above table, it would seem that scarcely any variety can be said to be wholly resistant to collar-blight. On the other hand, Grimes, Baldwin, and York Imperial have been reported as diseased frequently enough to indicate their susceptibility. Selby[11] states that in Ohio, Grimes, Maidens Blush, Sutton, Tompkins King, and Yellow Transparent are the most susceptible to "collar-rot." Ben Davis and Baldwin are moderately susceptible in Ohio.

Giddings says that in West Virginia, York Imperial usually appears to be quite resistant, an observation not borne out by reports in Pennsylvania.

PREDISPOSING FACTORS.

Judging from observations supplemented by the experience of orchardists in the State, the authors have concluded that there are five factors of some importance favoring the appearance of collar-blight. These are fertilization, mulching, cultivation, root-grafting, and the age of trees.

[11] Selby, A. D., Ohio Agric. Exp. Sta. Circular 133. 1913.

It has been demonstrated by Stewart[12] and others that the twig-blight form of fire-blight is much more severe on trees which have received stable manure or heavy applications of other highly nitrogenous fertilizers. The same holds true, according to our observations, of collar-blight and this is supported by the experience of many commercial growers who find that this trouble is much more prevalent where heavy and continuous applications of such fertilizers are used.

Mulching also is conducive to the appearance of collar-blight. It has been noticed frequently that orchards where heavy mulching was regularly practiced, especially if accompanied by fertilization, were more seriously affected by this disease than were orchards where this system was not employed. Both fertilization and mulching are conducive to rapid growth and to the development of more succulent inner bark where the blight organism works chiefly. These factors are undoubtedly important in rendering the host plant more susceptible to collar blight as well as to the other forms of fire-blight.

Cultivation has been thought by some growers to be an important factor in the appearance and spread of the disease. This has not been proved, but it seems probable that cultivation may be indirectly responsible for the spread of collar-blight, since wounds made at the collar and on the roots by the cultivator may frequently serve as a means of entrance for the organism.

From reports received it would appear that the system of propagation by root-grafting is conducive to the frequent appearance of collar-blight. Top-worked or budded trees on the other hand do not seem to be so commonly attacked. It seems probable that when an imperfect union results from root grafting an easy means of entrance is afforded the blight organism. The use of blight-susceptible stock may be a further factor in the severity of collar-blight.

The statistics compiled from various parts of the State show that the average age of trees at the time of infection by collar blight is between 12 and 13 years. The complete range for cases observed was from 7 to 20 years with few exceptions. These data are in

[12] Stewart, J. P. Report Pennsylvania Exp. Sta. 1910-11:467. 1912.

portant for they show that trees are most likely to be attacked at the time when they are most valuable. Other workers on collar-blight have made the same observations.

METHODS OF DISSEMINATION.

Inasmuch as the other forms of fire-blight, such as blossom-blight, twig blight, and fruit-blight, as well as canker-blight in some cases, are spread by insects, it seems logical to suppose that collar-blight also may be spread by such agents.

In 90% of the reports and observations made on collar-blight, apple tree borers were associated with the disease at the collar. Whether they are the direct carriers of the blight bacillus or are only secondary has not been determined as yet. Their presence there so frequently is suggestive, however, and they are certainly an important factor to be reckoned with. Whetzel[13], in New York, has also observed borers as being associated with collar-blight. As Whetzel suggests, it is possible that the borers serve primarily to open a place of entrance and that the bacteria are carried to the collar by other insects attracted there by the sap exuding from punctures made by borers.

Jones [14], in Ontario, Canada, has shown conclusively that the "fruit bark beetle," *Scolytus rugulosus*, is frequently the direct carrier of *Bacillus amylovorus*, which causes canker-blight on the limbs and trunks of pear trees. The same writer[15] has shown also that *Aphis Pomi* and *Schizoneura lanigera* are responsible for 50% of the twig-blight on apple trees before the blossoming period and practically all cases after the blossoming period.

The woolly aphis, *Schizoneura lanigera*, was reported present in Pennsylvania in all cases where collar blight was present in the orchard, and, according to the observations of the authors, it is commonly found in the blighted areas. It is quite possible that this insect may be the carrier of the blight organism to the wounds made by borers, as it is known that the aphides commonly congregate wherever any exudations of sap occur. Whether they also may cause collar blight infection independently of previous wounds

[13] Whetzel, W. H. Cornell Agric. Exp. Sta. Bull. 236:118-110. 1906.

[14] Jones, D. H. *Scolytus rugulosus* as an Agent in the Spread of Bacterial Blight on Pear Trees, Phytopath. 1:149-151. 1911.

[15] Jones, D. H. Ann. Rept. Ontario Agric. Col. and Exp. Farm. 35:125-130.

is not known, but such may be the case. There seems to be good evidence to show that insects of one kind or another may be responsible for a considerable amount of collar-blight.

Other means of dissemination may be the tools used in the removal of borers; careless cultivation resulting in wounds at the collar; the presence of suckers at the roots of trees which are frequently blighted and by means of which the bacterial organisms may gain entrance to the collar (Fig. 6); the removal of suckers

Fig. 6—Collar-blight originating through the sucker at left marked by an X.

from the base of trees during the growing season and neglect to protect the cut surface which remains, and the injuries caused by mice, rabbits, and such animals.

TREATMENT AND METHOD OF CONTROL.

From the nature of the causal organism, and the long-tried methods for its control by surgical treatment, it has seemed that the application of such methods might be of practical use in treating trees blighted at the collar. On this assumption the junior author carried out a series of experiments in 1912, to ascertain whether collar-blight might be successfully checked by cutting out the diseased areas. Trees in all stages of the blight were chosen

Fig. 7—Typical Collar-blight, showing proper method of cutting back into healthy bark before treating with paint.

and from the results of these experiments it would seem possible to cut out collar-blight with good chances of saving the trees, provided they are not more than half girdled. If more than half

girdled, it hardly seems advisable to attempt to save the tree unless bridge-grafting can be resorted to advantageously.

It is also important to thin the fruit out well on treated trees, in order that the maximum amount of food may be used by the tree to form callus growth and thus hasten recovery.

If the diseased trees have passed beyond the period favorable for surgical treatment, they should be removed at once, as they are

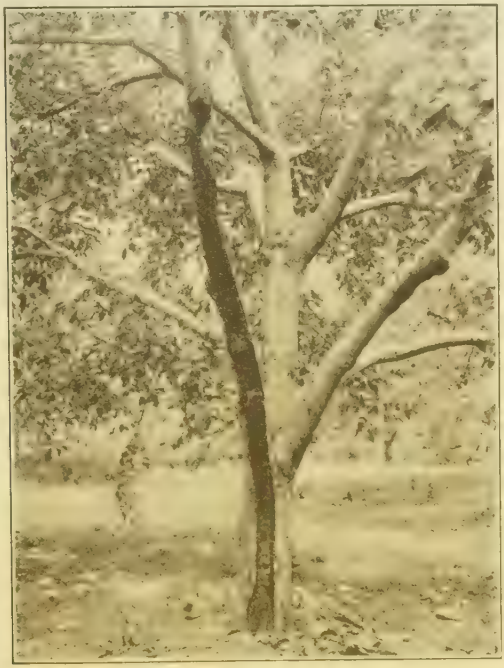


Fig. 8—A case of Collar-blight which progressed rapidly up into the limb. Properly cut out and treated.

likely to be a serious source of infection to other trees in the orchard. As previously indicated, it seems probable that almost any sort of boring or sucking insect may carry the blight organism from such trees to others, especially such as have been weakened

by some cause, and there establish new infection centers. It is, therefore, essential not only to remove immediately trees which are hopelessly diseased, but to be very careful during a search for borers to avoid carrying the blight organisms on the tools. Ap-

Fig. 9—Showing a Collar-Blighted area properly cut out and treated with asphaltum.

proved methods of insect control, especially with regard to borers and woolly aphis, would appear also to be important.

For proper cutting out of the diseased areas a heavy chisel and mallet are desirable. The soil should be removed from about the diseased collar and roots. All diseased roots should be removed from the tree as completely as practicable.

Cut to a depth of at least 1 to 2 inches into the healthy, green bark surrounding the diseased spot, being careful to remove all infected tissue (Fig. 7). Sterilize the surface of the wound with corrosive-sublimate (bichloride of mercury) 1:1000 strength, or with concentrated lime-sulphur solution. The wound should be allowed to dry thoroughly, after which a thick coat of white lead and linseed oil should be applied. After the latter has dried, the soil should be carefully replaced about the collar. In the treatments of wounds, different asphaltic compounds were experimented with and some proved very successful. Owing, however, to the injurious effects of some asphaltic compounds, the authors hesitate to recommend their use until their safety has been established by more complete experiments on fruit trees. A coat of white lead seems preferable. Figures 8 and 9 show trees successfully treated and painted with asphaltum.

FIRE-BLIGHT AND OTHER RELATED FORMS OF BLIGHT

DIFFERENT FORMS OF FIRE-BLIGHT.

There are four other forms of blight caused by the same organism *(Bacillus amylovorus)* that causes collar-blight. These

Fig. 10—A typical case of Blossom-blight in early stages.

forms are known as blossom-blight, fruit-blight, twig-blight, and canker-blight. Apple, pear, and quince trees are especially susceptible.

Blossom-blight is evident by a general browning of the flower clusters, which eventually become entirely blackened (Fig. 10). Such infection often extends downward through the fruit-spurs into the twigs and frequently develops canker-blight. This form of fire-blight was especially serious throughout Pennsylvania during the spring of 1915.

Fruit-blight usually appears any time after the fruit starts to develop until it is at least one inch in diameter. It usually starts as brownish or much darkened areas, which progress rapidly until the entire fruit is involved (Fig. 11). The blighted fruits are usually

Fig. 11—Fruit-blight. Note especially the apple at left showing characteristic appearance.

covered with bacterial exudations that make them sticky to the touch. This form of blight often accompanies twig-blight.

Twig-blight is the most prevalent form. Its presence is indicated by the blighting of the twigs from the tips downward. The leaves turn brown and cling strongly, giving badly blighted trees the appearance of having been scorched by fire, hence the term fire-blight. The young bark and sap-wood are blackened.

Canker-blight is usually the result of the bacteria working into the larger limbs from the infected twigs, fruit-spurs, or water-sprouts (Fig. 12). Injury by mechanical means also may permit

Fig. 12—Newly formed Canker-blight. Organism entered trunk through spurs.

the entrance of the organism. Injury by insects, such as the fruit bark-beetle, or by birds may possibly be responsible. The cankered areas are at first small in outline, but may later progress into a long, extended canker and often completely girdle the limb, so that the

outer parts of the limbs are entirely killed. These cankers are usually typical, being much roughened or depressed areas, which are sharply marked off from the healthy tissue by a line of demarcation. They are in most respects similar to collar-blight in mode of development. These blight cankers on the limbs of the upper part of the trunk are frequently referred to as "hold-over cankers." The bacteria remains alive through the winter in the tissue at the margin of these cankers, and in the spring, when the sap becomes active, they renew their activity. Bacterial exudations are usually emitted and different insects feed on this ooze and then visit the blossoms, fruits or twigs, and rapidly spread the infection. To reduce the spread of fire-blight it is essential to remove these cankers.

Fig. 13—Showing pear trees severely infected with Fire-blight.

Warm, moist weather favors the development of blight and makes the younger growth more susceptible. Fire-blight can be controlled by giving careful and prompt attention to the removal of

all infected parts. Infected twigs and water-sprouts should be cut at least six inches below any sign of bark discoloration and all cuts should at once be disinfected with corrosive sublimate (bichloride of mercury) at the strength of 1:1000 parts of water or about 1 tablet to one pint of water. All canker-blight should be cut out and the cuts disinfected and painted over with white lead and linseed oil. This will protect the cut surface against infection by other organisms and facilitate the formation of callus growth.

In order to eliminate or to reduce the blight to a minimum, careful inspection must be resorted to at least every week from blooming time until the fruits are one-third to one-half grown, and any blighted parts, however small, removed at once. Only by such careful inspection and removal, and the co-operation of all fruit growers in the locality, can blight be controlled.

Blossom-blight is spread chiefly by nectar-gathering insects, such as bees, and for that reason this form of fire-blight is most difficult to control. The insects chiefly concerned in spreading the twig and fruit blight are probably aphides and the red bugs, and the control of such pests should greatly reduce the spread of these forms of fire-blight. Many of these insects may be controlled by using the combination spray of one pint 40% nicotine solution to each one hundred gallons of diluted or self-boiled lime-sulphur. The general plan for the first two sprayings of apples and pears may be followed. The first application should be made when the blossoms are just showing pink and a second when the petals are two-thirds fallen.

It is also worth while to give attention to such cultural methods as will tend to increase the disease-resistance of the trees. A moderate well-hardened growth is not as susceptible as either a large and succulent growth or a weak and feeble growth. The results of experiments have shown that attention to the character of the growth is frequently sufficient to control the forms of fire-blight.